



Bolko von Roedern, MS 3212
National Center for Photovoltaics
National Renewable Energy Laboratory
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Golden, CO 80401

10/13/2005

Dear Bolko,

This is the first quarterly report of our project under the current Thin Film Partnership Program (Subcontract No. XXL-5-44205-12 to University of Nevada, Las Vegas: Characterization of the electronic and chemical structure at thin film solar cell interfaces). A brief summary and details of our activities are given below. This report is in fulfillment of the deliverable schedule of the subcontract statement of work (SOW).

Summary

This project is devoted to deriving the electronic structure of interfaces in Cu(In,Ga)(S,Se)_2 and CdTe thin film solar cells. By using a unique combination of spectroscopic methods (photoelectron spectroscopy, inverse photoemission, and X-ray absorption and emission) a comprehensive picture of the electronic (i.e., band alignment in the valence and conduction band) as well as chemical structure can be painted. The work focuses on (a) deriving the bench mark picture for world-record cells, (b) analyze state-of-the-art cells from industrial processes, and (c) aid in the troubleshooting of cells with substandard performance.

First funds for this project became available in the middle of July 2005. Since then, the workforce of the group was expanded to the size required for this project. The experimental instrumentation at UNLV – a four-chamber ultra-high vacuum surface analysis and modification system – was commissioned and put to routine use after its relocation from the University of Würzburg, Germany. Contacts within the Thin Film PV Partnership Program were established to secure a supply of adequate samples. These samples are currently in preparation and will be analyzed both in the lab at UNLV as well as in our upcoming beamtime at the Advanced Light Source, Lawrence Berkeley National Laboratory (Nov. 2 – 13, 2005).

Detailed Description of the Activities:

1. Establishing the workgroup at UNLV

First funds for this project became available in the middle of July 2005. Therefore, a substantial fraction of the initial activity to date was devoted to the expansion of the workforce for this project. With the arrival of Monika Blum, a graduate student from the Uni-

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versity of Würzburg, Germany, in late July 2005, and of Dr. Marcus Bär, a post-doctoral fellow (recipient of the prestigious German Emmy Noether Scholarship of the Deutsche Forschungsgemeinschaft) in mid-August, this expansion was fortunately very fast and successful.

Dr. Bär performed the research for his doctoral thesis at the Hahn-Meitner-Institute in Berlin, Germany, specializing in the optimization of interfaces between novel buffer layer materials and Cu(In,Ga)(S,Se)_2 thin film solar cell absorbers by chemical surface pretreatments. At UNLV, his primary focus is on modifying interface properties for an optimization of thin film solar cells with wide-gap chalcopyrite absorbers. In January 2006, the group will further be joined by Dr. Lothar Weinhardt from the University of Würzburg, Germany. Dr. Weinhardt has pioneered the use of the combination of UV- and Inverse Photoemission for the routine study of band alignment at thin film solar cell interfaces, as well as the to-date least intruding cleaning method for air-exposed thin film chalcopyrite surfaces (50 eV Ar^+ ion “sputtering”). Both post-docs bring significant expertise in optimization and analysis of surfaces and interfaces in thin film solar cells into this project, and both have published extensively in this area. Monika Blum and Dr. Weinhardt are/will be funded through this project. Three undergraduate Science students (John Peiser, Jared White, and Kyle George) from the UNLV Honors College have also joined the group and will be involved with this project. Fig. 1 shows a picture of the group to date.

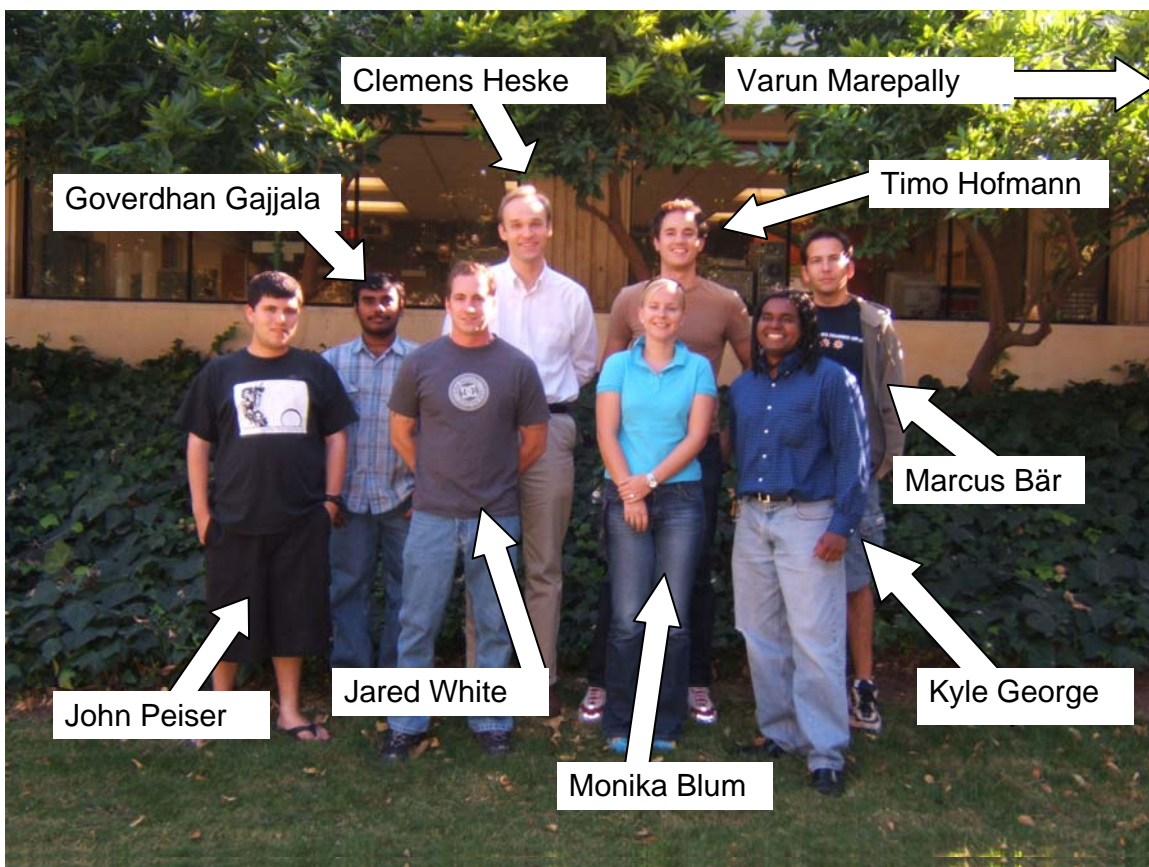


Fig. 1: Picture of the workgroup.

2. Commissioning of the four-chamber ultra-high vacuum surface analysis and modification system

The apparatus for the lab experiments at UNLV was successfully commissioned and optimized for routine investigations with X-ray (XPS) and UV (UPS) photoelectron spectroscopy. All necessary items for Inverse Photoemission (IPES), such as a new low-energy/high-current electron gun, a Dose-type photon counter tube, new counting electronics and software, were assembled and installed into the chamber. A high-stability, high-voltage power supply is ordered and due for delivery at the beginning of November, at which point first IPES spectra will be collected. A picture of the instrument (before installation of IPES) is shown in Fig. 2.

In the first project quarter, an electronic shortage problem with the electron analyzer was observed and removed. Nevertheless, we plan to replace the existing electron analyzer by a modern high-transmission instrument at the end of this calendar year. Funding for this replacement has recently been obtained, and the expected downtime is estimated to be about two weeks. The new spectrometer will allow the collection of spectra with higher resolution at significantly reduced experiment times.

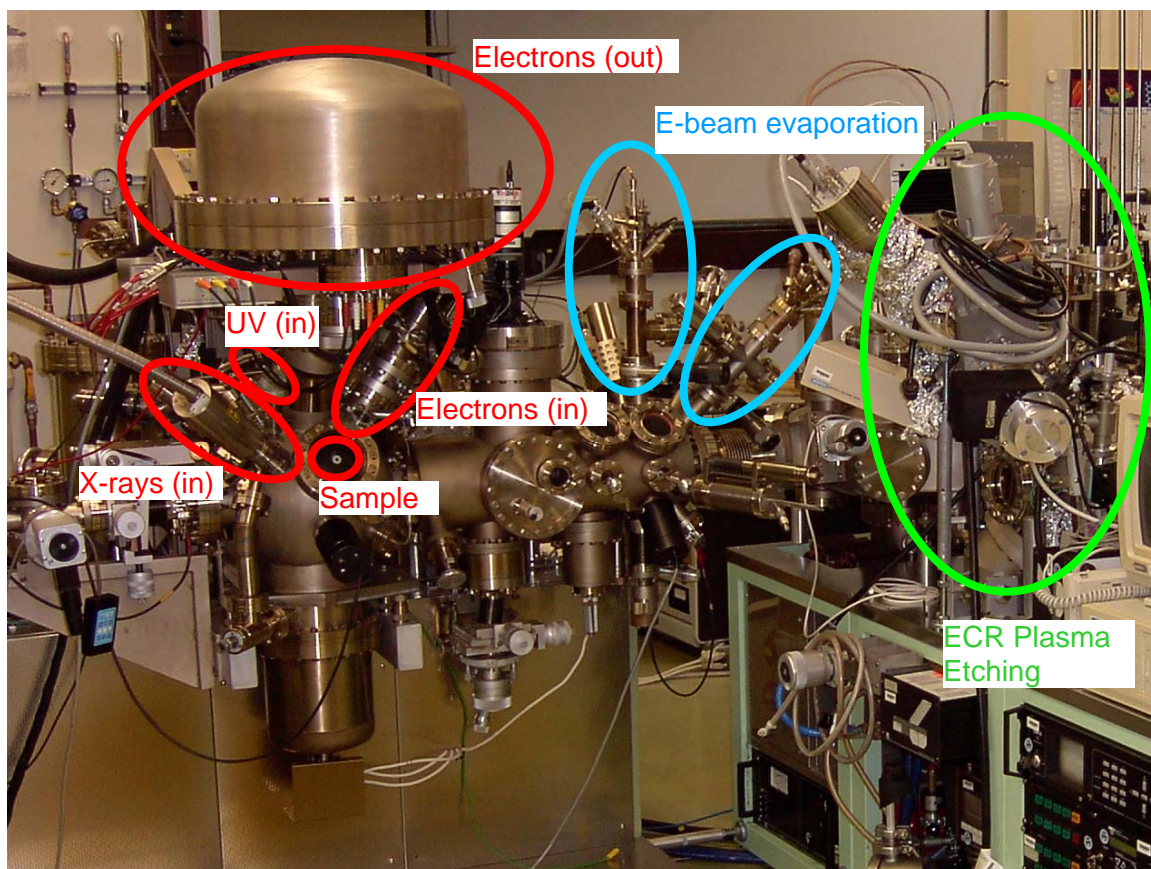


Fig. 2: Picture of the four-chamber ultra-high vacuum surface modification and analysis instrument at UNLV.

3. Establishing collaboration contacts within the TFPPP

After commissioning of the instrument, several potential collaborators within the TFPPP were contacted for the planning of joint experiments. Currently, samples are in preparation for establishing the benchmark picture of the electronic structure at the CdS/Cu(In,Ga)Se₂ interface (with K. Ramanathan). Further experiments on other interfaces in CIS- and CdTe-based cells are in planning, both in the lab at UNLV as well as in our upcoming beamtime at the Advanced Light Source, Lawrence Berkeley National Laboratory (Nov. 2 – 13, 2005).

If you have any questions, please do not hesitate to call me at (702) 895-2694.

Sincerely,

C. Heske
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University of Nevada, Las Vegas

CC: C. Lopez